WILL INCREASING CORN ACREAGES IN WISCONSIN NECESSARILY LEAD TO HIGHER RUNOFF SEDIMENT AND PHOSPHORUS LOSSES?

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Currently there are more than 600,000 acres in Wisconsin enrolled in the USDA's Conservation Reserve Program (CRP). The contracts for approximately 44% of these acres may expire in 2007 and 2008 (Farm Service Agency, 2006). The fate of these lands is uncertain, though a likely scenario, given current rising demand for corn, is that at least a portion will go into a corn-based row crop rotation. These CRP lands were removed from production because of their vulnerability to erosion. Soil and nutrient losses from CRP lands kept in perennial cover are extremely low. If these highly erodible lands go into corn production, will the increasing runoff sediment and nutrient loads lead to disastrous water quality declines? Are there ways to manage corn on former CRP lands that will keep the soil quality and conservation gains from the Conservation Reserve Program from being totally lost?

To answer these questions, I used the cropland soil erosion and runoff phosphorus loss estimation capability of the Snap-Plus nutrient management planning software to evaluate the consequences of different corn rotations and tillages on highly erodible fields (Snap-Plus, 2006). Snap-Plus includes RUSLE2, the Natural Resource Conservation Service's (NRCS) current field-level soil loss estimation tool for conservation planning, and the Wisconsin P Index calculator. The Wisconsin P Index estimates phosphorus (P) delivery from a field to the nearest surface water (Bundy and Good, 2006). If the distance from the field to the stream in the program is set at zero, the P Index value can be used as an indicator of field-edge runoff losses. The RUSLE2 soil loss calculations have been extensively validated (Foster, 2005), and both the RUSLE2 and the P Index appear to be doing a reasonable job of assessing the effects of varying management practices and field conditions on runoff sediment and P losses from Wisconsin fields (CALS, 2005). An additional Snap-Plus/RUSLE2 output that I used for assessing the cones-quences of establishing corn rotations on soil quality is the Soil Conditioning Index, a measure of soil organic matter status over a rotation.

The information requirements to assess soil loss with Snap-Plus are: field's location (county), soil type, slope, slope length, crop rotation, yields, and tillage practices. Additional requirements to calculate P runoff potential with the P Index are soil test P and manure and P fertilizer rates, timing, and method of application. For representative highly erodible field sites, I selected eleven soil mapping units with steep (soil mapping unit "D") slopes from counties with significant CRP acreages (Table 1). Conservation Reserve Program acres are predominately in the southwest, south central, and northwest parts of the state and in a few of the eastern counties. The fields I chose are not statistically representative of CRP sites in Wisconsin as the data that would allow this is not available, but they are examples of sites that might be in CRP. For slopes and slope lengths, I used the default ("typical") values assigned by NRCS for each mapping unit. I assigned a moderate soil test P value of 20 ppm to each field.

For each field, I ran Snap-Plus with ten different crop rotation and tillage combinations: established grass hay (cut three times during the growing season), no-till continuous corn for grain (Cg: NT); strip-till continuous corn for grain (Cg: ST), no-till continuous corn grain with half of the stalks baled (Cg-baled: NT), no-till rotation with 2 years of corn for grain followed by

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soybeans (Cg-Cg-S: NT), continuous corn for grain with a one-pass tillage - a field cultivation (Cg: Fcult), chisel-plowed continuous corn for grain (Cg-CP), no-till continuous corn silage (Cs: NT), continuous corn silage with one-pass tillage (Cs: Fcult), and chisel-plowed continuous corn silage (Cs-CP). All operations were conducted on the contour. The difference between the no-till and strip till managements is that the strip-planter disturbed a wider zone of the surface than the no-till planter. RUSLE2 soil loss estimates are quite sensitive to yield levels in corn for grain and decrease with increasing yields; therefore, it is important to select representative yields to get truly representative soil loss estimates. For corn yields, I used the 75th percentile yield for each soil's potential corn yield range as identified in the University of Wisconsin-Extension soil fertilizer recommendations (Laboski et al., 2006). No manure or fertilizer applications were included in this Snap-Plus analysis.

Table 1. Location and site characteristics of fields used for soil and phosphorus loss estimations

Location (County)	Field slope	Field slope length	Soil map symbol	Soil name	Surface texture	Tol. soil loss (T)
	%	ft				T/acre/yr
St. Croix	16	100	AmD2	Amery	loam	5
Pierce	16	30	167D2	Derinda	silt loam	3
Iowa	14	150	DhD2	Dodgeville	silt loam	4
Grant	12	150	DuD2	Dubuque	silty clay loam	3
Dane	16	100	DuD2	Dunbarton	silt loam	2
Eau Claire	16	85	EmD2	Elkmound	loam	2
Trempealeau	16	150	GaD2	Gale	silt loam	3
Dunn	16	100	275D2	Hayriver	Fine sandy loam	3
Fond du Lac	16	100	HmD2	Hochheim	loam	5
Rock	16	100	KdD	Kidder	sandy loam	5
Richland	16	100	254D2	Norden	silt loam	3

Erosion

Estimated erosion increased with increasing crop residue removal and soil disturbance across all sites (Fig.1 and Table 2). Estimated soil loss for grass hay was minimal for all sites (0.1 ton per acre). Soil loss was greater for all the corn rotations. All no-till corn for grain soil loss, however, was below 1 T/acre/year, and soil loss for strip-tilled corn for grain was below the NRCS standard for tolerable soil loss (T) at all sites. The fields with soils with the lowest T values (2 T/acre/year, Dunbarton and Elkmound soils) could not meet T if the corn stalks were baled or if soybeans were added to the rotation every third year. Six of the fields with corn for grain could not meet T with one-pass tillage and only two could meet T with a chisel plow system (Hochheim and Kidder soils). Fields with corn silage had very high RUSLE2 soil losses that were 4 to more than 10 times T and 80 to 400 times more than that for the grass hay, even with no-till.

Less steep fields than these would be expected to lose less soil under the same rotations. On one of the most vulnerable soils in the example group (Dunbarton), the no-till corn-soybean rotation that did not meet T for the example field would meet it with a lower slope (DuC2, 9% slope). On one of the least erodable soils in the example group (Hochheim), no-till corn silage could meet T on a 9% slope (HmC2). One interesting observation that came from some additional Snap-Plus runs with these fields is that, although conducting all operations on the contour was very important for keeping soil loss estimates low for all systems with tillage, including strip tillage, no-till planting up-and-down the slope rather than on the contour generally only increased soil loss by 0.1 T/a/yr.

Figure 1. Mean estimated rotational erosion for all example fields by rotation and tillage.

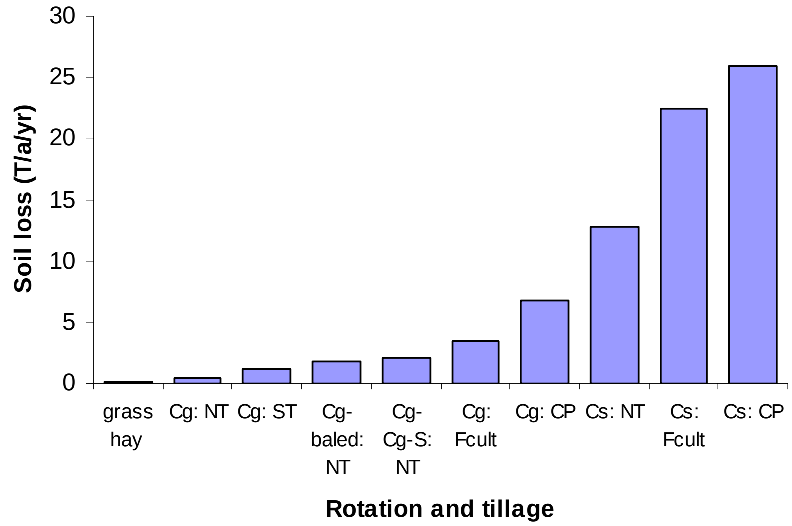


Table 2. Mean, maximum and minimum estimated soil loss for all example fields by rotation and tillage in T/a/yr. †

	Grass hay	Cg: NT	Cg: ST	Cg-baled: NT	Cg-Cg-S: NT	Cg: Fcult	Cg: CP	Cs: NT	Cs: Fcult	Cs: CP
Mean	0.1	0.5	1.2	1.8	2.2	3.5	6.8	13	23	26
Max	0.1	0.8	2.3	3.2	3.5	5.7	10.7	20	37	44
Min	0.1	0.2	0.4	0.7	1.0	1.7	3.1	8	13	15

† Abbreviations: Cg = Corn for grain, S= Soybeans, Cs = Corn silage, NT= No-till, ST=Strip-till, CP= Chisel plow, Fcult = Field cultivation

Runoff Phosphorus Losses

For these example fields, the primary form of P in runoff is expected to be particulate, or sediment-bound P. Consequently, the trend toward increasing P in runoff with increasing crop residue removal and soil disturbance mirrors that for soil loss (Fig. 2). All of the fields were assigned the same soil test P (20 ppm) for this analysis; P losses would be proportionately lower if the soil test P was lower and proportionately higher at higher soil test P values. In this analysis, none of the fields received manure or broadcast applications of P fertilizers. Such applications would have lead to increased risks of P in runoff in forms not directly bound to sediment.

Soil Conditioning Index

The Soil Conditioning Index (SCI) is a comparatively new index calculated by RUSLE2 and used by the NRCS to indicate the effect of a management system on soil organic matter (USDA-NRCS, 2005). It takes into account crop biomass additions and removals, field operations, and erosion. If the calculated SCI value is positive, organic matter will be increasing with the rotation and the reverse is true if it is negative. An illustration of SCI values with differing rotations for one example field is shown in Fig. 3. Almost all of the rotations with corn for grain (the exception is except for Cg: CP) had positive SCI values, while all of the corn silage rotations had negative SCI values. All of the example fields exhibited the trends shown in Fig. 3.

Figure 2. Mean rotational average P Index values for all example fields by rotation and tillage.

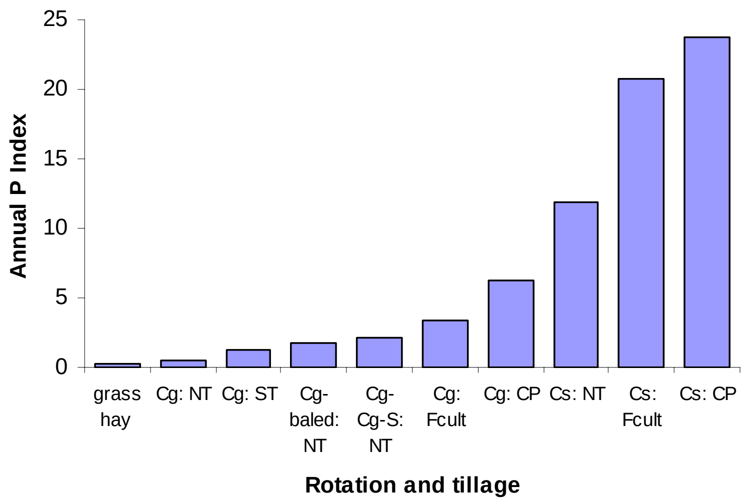
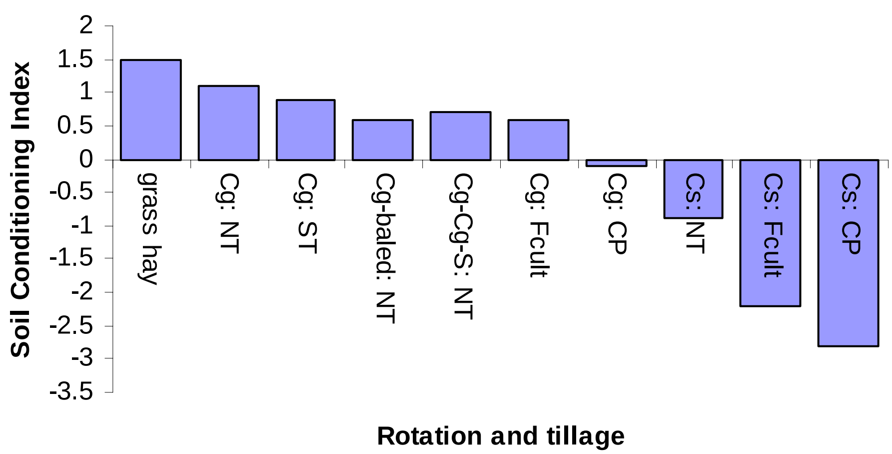


Figure 3. Soil conditioning index for a Grant County Dubuque silty clay loam field, 12% slope with different rotations and tillages.



Can the Beneficial Effects of Crop Residues Be Replaced with Manure Applications?

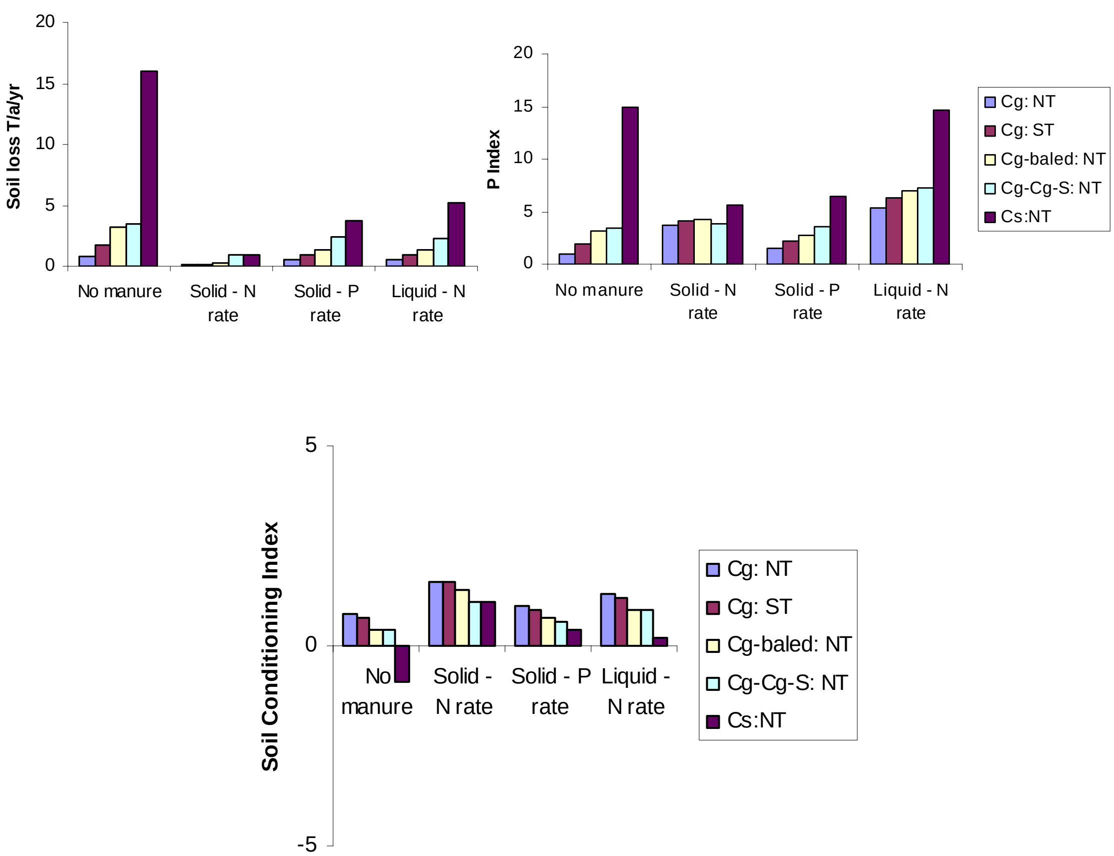
Expected increases in soil and nutrient losses and decreases in soil organic matter with corn rotations are directly related to the quantity of crop residues left on the soil surface. In situations where corn silage is more valuable to growers than corn for grain, is there a way to remediate the removal of the corn plant by replacing it with some other organic matter on the soil surface? Currently, the most common organic matter amendments in Wisconsin are animal manures.

Adding manures to the soil surface can reduce soil loss but also increases the amount of P and other nutrients on the surface that can be washed away in runoff.

To answer the question of how much manure applications can be used to reduce sediment losses without increasing the risk of runoff P losses to unacceptable levels, I ran Snap-Plus for two of the example fields using several rates and kinds of manure applications in the rotations. Since most of the example fields are too steep for winter applications, I set the manure applications in the fall after harvest. The manure applications were: solid dairy manure with bedding (24% dry matter) applied at a rate to meet the nitrogen (N) need for corn (40 T/a), solid dairy manure applied to meet the P recommendations for corn (8 T/a), and liquid dairy manure (6% dry matter) to meet the corn N rate.

Soil loss was dramatically reduced with the heavier dairy manure application as shown for the Dunbarton silt loam in Fig. 4. It was below T for this soil (2 T/a/yr) for all no-till rotations, even continuous corn silage. The manure applications also increased SCI values in proportion to the manure dry matter applied. No-till corn silage had a positive SCI, indicating positive organic matter accumulation, with any of the three rates of manure. Conversely, the manure applications, particularly when applied to meet corn N needs, dramatically increased runoff P loss potential.

Figure 4. Estimated soil loss, P index, and soil conditioning index values for a Dane County Dunbarton silt loam, 16% slope, with varying rates and types of unincorporated dairy manure applications, rotations and tillages.



Conclusion

Converting CRP from permanent grass lands to corn will certainly increase sediment and phosphorus loads in runoff from these areas. However, with careful management that minimizes tillage and retains a significant amount of crop residue on the surface, these losses will be minimized. Harvesting the entire corn plant as is done for corn silage will lead to soil losses that are orders of magnitude higher than tolerable soil loss. This can be mitigated with replacement of the plant material with some other organic material such as manure. Unincorporated manure applications, however, will increase the risk of phosphorus losses in runoff.

The Snap-Plus software is designed to be used by growers, agronomists and other agricultural professionals in Wisconsin. The field level information it requires is readily available to growers. It can help growers assess potential sediment and phosphorus losses resulting from converting grass lands to row crops and can help them pick management practices to minimize these losses.

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